ROTATING TURBULANCE CONVECTION IN STRATIFIED AMBIENT WITH APPLICATIONS TO THE LABRADOR SEA

Siavash Narimousa
University of Southern California, Mech. Engg. LA, CA 90089-1453 / /
Narimosa@mizar.usc.edu
213-740-0499
Fax 213-740-8071
Award # N00014-93-01-0489

GOALS

The long term goal of this research is to understand penetrative, turbulent convection in the Arctic ocean and its adjacent seas, in particular the Labrador Sea.

OBJECTIVES

The objective is to model and study turbulent convection into stratified ambient. We will utilized the results to predict winter time convective events that occur as a result of intense cooling and/or freezing of the surface of the Arctic ocean and its seas, such as the Labrador Sea.

APPROACH

Our objectives will be achieved via Laboratory modeling, basic theories and scaling arguments and computational methods such as particle image analysis technique.

TASKS

We have completed our first serious of laboratory experiments on turbulent convection into linearly stratified ambient. The experimental apparatus consists of a cylindrical tank (150 cm in diameter and 30 cm deep) that was mounted on a turn table. It took about one day to fill up the tank with a linearly stratified (the density of the water increases linearly with its depth) water column and to model the earth rotation rate it took about 24 to 48 hours to bring the system into a solid body rotation. A transverse conductivity probe was used to measure the initial density of the water column and during the running of a given experiment. The tank rotation rate and the vertical motion of the conductivity probe was controlled by a computer via two stepping motors and an Anaheim automation box. A data acquisition board enabled us to store the density data in a computer file for later analysis. When an experimental system was in a solid body rotation a convection source (a model of cooling and or freezing) that was located at the top surface of the water column (in the center of the tank) was activated and released denser salt water into the underlying stratified ambient. As a result a growing turbulent convective flow was

Report Documentation Page

Report Documentation Page	*Form Approved OMB No. 0704-0188*

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**
4. TITLE AND SUBTITLE **Rotating Turbulence Convection in Stratified Ambient with Applications to the Labrador Sea**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Southern California, Los Angeles,Department of Mechanical Engineering,Los Angeles,CA,90089**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT **unclassified**	b ABSTRACT **unclassified**	c THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

generated which then penetrated rapidly to an equilibrium depth where it began to propagate horizontally in the form of a front. Later, due to the effect of earth rotation, meso scale vortices were generated at the edge of the front. To reveal the structure of the flow field foreseen dye and small (1 mm) neutrally buoyant particles were illuminated by vertical and horizontal sheets of lights, separately. The most important results of our study are as follows;

RESULTS

The convective flow will penetrate rapidly to an equilibrium depth, characteristics of which is given in Narimousa (1997) and Visbeck et al. (1996).

At the equilibrium depth the convective flow will propagate horizontally in the form of a front and at first cyclonic vortices will be generated at the edge of the front around the convection source .

After about few rotation periods a large subsurface, anticyclonic vortex forms at the base of the convective flow at the level of the equilibrium depth. The mean radius of the anticyclone is about the same size as that of the source itself.

Eventually, the anticyclone will split into two smaller anticyclones and leave the area beneath the source.

Later, a new subsurface anticyclone will form and replace the old one beneath the source and the splitting process in (d) will be repeated.

The generated subsurface anticyclones continue to grow in upward direction until they reach a height equal to that of the equilibrium depth. As a result, the subsurface anticyclones dominate the central part of the convective system and do not allow new cyclonic vortices to form. Characteristics of the subsurface anticyclones (size, velocity etc.) are given in Narimousa (1997).

IMPACTS

The central Arctic Ocean: We have estimated an equilibrium depth of about 150 meter which is inside the linear stratified pycnocline of the Arctic ocean. We have predicted that at the equilibrium depth anticyclonic vortices with mean diameter of about 21 kilometer and maximum velocity of about 31 cm/s will be generated inside the pycnocline of the central arctic ocean. These predictions are in an excellent agreement with the field measurements reported by Newton et al. (1974), Hunkins (1974), Manley and Hunkins (1985) and D\'Asaro (1988).

The Labrador Sea: The Labrador Sea is weakly, linearly stratified (Lazier (1994)), and we have estimated an equilibrium depth of about 1400 meter for this region. We have predicted that at the equilibrium depth several subsurface anticyclones with mean diameter of about 21 kilometer and maximum velocity of about 31 cm/s will be generated. Also, we have predicted that initially at least 3 cyclonic vortices with mean diameter of about 16 kilometer will be generated around the convection source.

APPLICATIONS

Results of our study have been applied to the prototype field situations in the Greenland sea, the central Arctic ocean and Golfe du lions south of France. We should note that our model has predicted most of the measured field values correctly, for details see Narimousa 1996 and 1997.